MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2015/2016

EOP 3056 – OPTICAL METROLOGY AND TESTING

(All sections / Groups)

10 MARCH 2016

9.00 a.m - 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 5 pages with 4 Questions only.
2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

Question 1

Figure Q1 illustrates a system that measures the quality of lenses. The viewing microscope observe Newton ring pattern over the lens surface.

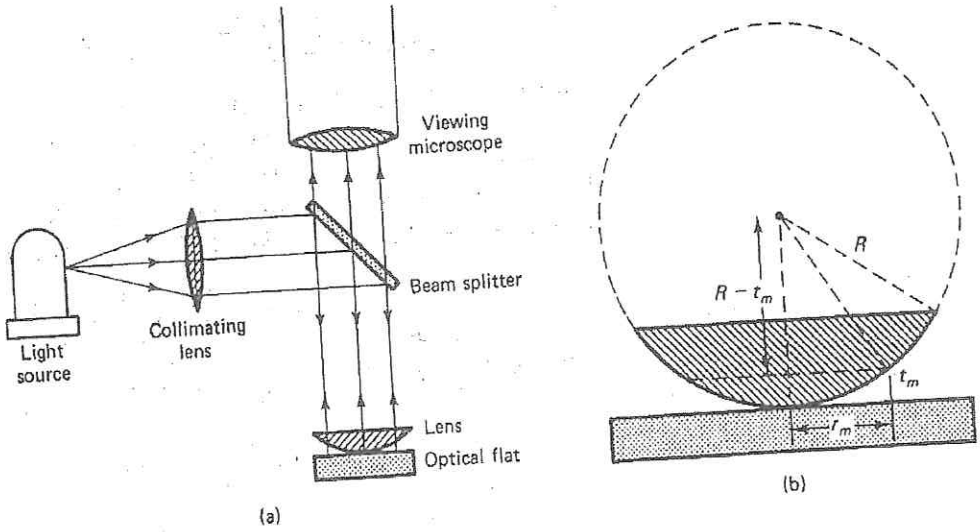

Figure Q1

a. One of quality measures is the radius R, that derived from the Newton ring observation. Proof that the m^{th} bright ring is

$$r_m^2 = (m+1/2)\lambda R / n_f .$$

[10 marks]

b. Explain how the Newton's rings can be used to determine the quality of the spherical surface of a lens.

[5 marks]

c. A Newton's ring apparatus is illuminated by light with two wavelength components. One of the wavelengths is 546 nm. If the eleventh bright ring of the 546-nm fringe system coincides with the tenth ring of other, what is the second wavelength? Explain the advantages of using bi-wavelength setup.

[6 marks]

d. From Q1 (c), what is the radius at which overlap takes place and the thickness of the air film? The spherical surface has a radius of 1m.

[4 marks]

Continued .....

Question 2

As an equipment maker, you are required to examine the fluid temperature variation within a chamber. The design is given with 2 transparent window to view fluid temperature and flow condition. It is observed that the steady state relationship of refractive index, n with temperature, T is:

$$n = T_0 - kT, \qquad k > 0.$$

a. Suggest a suitable technique to measure the refractive index change. Explain why you choose this technique.

[4 marks]

b. Using a diagram, illustrate the measurement platform you suggested for this measurement.

[4 marks]

c. Explain the principles behind the measurement platform.

[6 marks]

d. State the assumptions in making the measurement.

[2 marks]

e. Explain using a flow chart, the methodology of finding T, using the measurement.

[5 marks]

f. List the limitations of the measurement platform. Suggest 2 possible discrepancies in your measurement if the system does not achieve its steady state during the measurement.

[4 marks]

Continued .....

Question 3

As a quality assurance engineer, you are required to ensure the quality of a large (3 m in diameter) parabolic mirror. Specifically, the testing and quality evaluation can be digitized using a Shack-Hartmann Wavefront Sensor (SHWS) System (using lenslet array).

a. Using a diagram, explain how the SHWS can be used in the testing and quality assurance. For every slope measurement of the wavefront S, describe the phase of the wavefront as a function of the slope measurement (using zonal method).

[12 marks]

b. If the system can be simplified in linear equations form,

$$\vec{y} = A\vec{x};$$

where vector $\vec{y}$ is the slope measurement over M grid points (in one direction over a square grid, m x m = M), vector $\vec{x}$ is the phase of the wavefront over the lenslet surface.

Given the slope measured as below, find the phase of the wavefront. Interpret the results.

$$\vec{y} = \begin{bmatrix} 3 \\ 2 \\ 1 \\ 2 \\ 3 \end{bmatrix}; \qquad A^{-1} = \begin{bmatrix} 0.0195 & 0 & 0 & 0 & 0 \\ 0 & 0.0195 & 0 & 0 & 0 \\ 0 & 0 & 0.0031 & 0 & 0 \\ 0 & 0 & 0 & 0.0031 & 0 \\ 0 & 0 & 0 & 0 & 0.0098 \end{bmatrix}.$$

[6 marks]

c. Suggest a method to enhance the lateral resolution of the system. Explain the methodology using a diagram.

[7 marks]

Continued .....

Question 4

a. Using a diagram, explain how a passive system of your choice (give the name of the system) that can be used to measure 3D range data.

[13 marks]

b. Suppose the system suggested in Q4 (a) indicated a relationship between the expected range data (3D) as $\vec{Y}$ with the range of measured vector $\vec{x}$.

$$\vec{Y} = A\vec{x}$$

where A is the transformation matrix. Suggest a technique to estimate vector $\vec{Y}$.

[5 marks]

c. Using a diagram, explain double exposure holographic interferometry.

[7 marks]

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